Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of Amendment of Section 15.255 of the Commission's Rules	ET Docket No. 21-264

REPLY COMMENTS OF GOOGLE LLC

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October 18, 2021

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Google commends the Commission for its ongoing process to update its rules for the 57-71 GHz band (60 GHz band).[1] Comments from stakeholders throughout the ecosystem reflect the groundswell of enthusiasm for harnessing the 60 GHz band's unique characteristics to deploy a host of new technologies, many of which leverage low-power radars. From presence detection, gesture control, health monitoring, and augmented/virtual reality to broadband connectivity, American lives and livelihoods are being enhanced by unlicensed 60 GHz technologies. Swift Commission action to modernize rules for low-power radar operation will promote this development, while maximizing efficient and effective use of commercial spectrum.

INTRODUCTION AND SUMMARY

Commenters overwhelmingly agree that leveraging existing ETSI standards provides the best path to achieving technological neutrality and reasonable coexistence among unlicensed 60 GHz communications and radar technologies. Updating the Commission's rules consistent with Google's comments[2] would advance important policy objectives, including promotion of American leadership in wireless innovation and

[1] *In the Matter of Amendment of Section 15.255 of the Comm'n's Rules*, Notice of Proposed Rulemaking, ET Docket No. 21-264, FCC 21-83 (rel. July 14, 2021) (*NPRM*).
[2] *See* Comments of Google LLC in ET Docket No. 21-264 (filed Sept. 20, 2021) (*Google Comments*).

global regulatory harmonization. As Facebook, Intel, and Qualcomm state, "[n]o application should get any preference over any other in this important unlicensed band."[3] Updating 60 GHz radar rules as proposed by Google would remove the unnecessarily strict conditions that have been placed specifically on 60 GHz radar operation in the United States while also allowing communication systems to flourish in the band. Furthermore, this modernization would not increase the risk of harmful interference to current or prospective Earth Exploration-Satellite Service (EESS) (passive) operations in the 60 GHz band.

I. ETSI STANDARDS OFFER AN APPROPRIATE FRAMEWORK FOR MODERNIZING THE COMMISSION'S RULES.

Commenters are nearly unanimous that the Commission's 60 GHz rules need improvement. The rules' operating requirements have not kept pace with development of socially-beneficial technologies. In particular, updated rules are necessary to enable low-power mobile radars that are very unlikely to generate harmful interference. Such updates can be made in a manner that facilitates reasonable coexistence between communications and low-power radar technologies.

The vast majority of commenters agree with the Commission's tentative conclusion[4] that ETSI standard EN 305 550 provides an ideal starting point. This harmonized standard, which has been in effect for more than six years, forms the basis of regulations for the 60 GHz band implemented by the European Commission and relied on in more than 66 countries globally.[5] No party has come forward with evidence

[3] Comments of Facebook, Intel, and Qualcomm in ET Docket No. 21-264 at 2 (filed Sept. 20, 2021) (*FB/Intel/QC Comments*).
[4] *See NPRM* ¶¶ 24, 27, 28.
[5] Comments of Acconeer AB in ET Docket No. 21-264 at ii, 14, 24 (filed Sept. 20, 2021) (*Acconeer Comments*).

that compliance with regulations conforming to EN 305 550 has led to instances of harmful interference or an inability for unlicensed devices operating in 60 GHz frequencies to reasonably coexist. Rather, as Infineon observes, "ETSI 305 550 limits have been tested and deployed in several countries outside the European Union . . . [and] support an environment favoring successful sharing of the 60 GHz spectrum among its various users."[6]

As the Commission explained in its *NPRM*, regulatory alignment with ETSI EN 305 550 supports a host of public interest benefits.[7] Parties cite the importance of global regulatory harmonization to increasing product availability, enhancing consumer choice, and maximizing manufacturing and compliance testing efficiencies.[8] In particular, greater alignment with the ETSI standard by removing the reference to short-range devices for interactive motion sensing (SRIMS) in Rule 15.255 would promote technological neutrality and end a regime in which the Commission picks-and-chooses among radar use cases.[9] And, use of a largely ETSI-derived regulatory framework would provide new flexibility to enable future technological growth in the 60 GHz band.[10]

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[6] Comments of Infineon Tech. Am. Corp. in ET Docket No. 21-264 at 8 (filed Sept. 20, 2021) (*Infineon Comments*).
[7] *See NPRM* ¶ 24.
[8] *See Acconeer Comments* at ii, 14; Comments of the Alliance for Auto. Innovation in ET Docket No. 21-264 at 2-3, 7 (filed Sept. 20, 2021); Comments of Auto. Safety Council in ET Docket No. 21-264 at 2 (filed Sept. 20, 2021); Comments of Vayyar Imaging, Ltd. in ET Docket No. 21-264 at 4 (filed Sept. 20, 2021) (*Vayyar Comments*).
[9] Comments of Amazon.com, Inc. in ET Docket No. 21-264 at 11 (filed Sept. 20, 2021) (*Amazon Comments*); Comments of IEE Sensing in ET Docket No. 21-264 at 4-5 (filed Sept. 20, 2021) (*IEE Sensing Comments*); Comments of Texas Instruments, Inc. in ET Docket No. 21-264 at 5, (filed Sept. 20, 2021) (*Texas Instruments Comments*).
[10] *See, e.g., IEE Sensing Comments* at 1.

II. UPDATED COMMISSION RULES SHOULD PROMOTE REASONABLE COEXISTENCE AMONG UNLICENSED TECHNOLOGIES.

All unlicensed spectrum technologies "operate under the fundamental condition that they are not protected against harmful interference" and must not cause harmful interference.[11] Commenters throughout the 60 GHz ecosystem agree that revisions to the rules should incorporate this expectation of cooperative spectrum sharing (i.e., reasonable coexistence) among unlicensed technologies.[12] To that end, two proposals—one that would impose an onerous 2 millisec off-time condition on top of an overly-restrictive duty cycle limit specifically on low-power radars,[13] and another that would retain existing rules based on a preference for 802.11ad radars[14]—should be rejected outright for violating the foundational principles of reasonable coexistence and maximal technological neutrality.

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[11] *See In the Matter of Terrestrial Use of the 2473-2495 MHz Band for Low-Power Mobile Broadband Networks; Amendments to Rules for the Ancillary Terrestrial Component of Mobile Satellite Service Systems*, Report & Order, 31 FCC Rcd. 13801, ¶ 29 (2016). *See also* 47 C.F.R. § 15.5 (general conditions of unlicensed device operation); *NPRM* n.2 ("operator of a Part 15 device has no vested right to continued use of any given frequency, must accept interference that may be caused by the operations of authorized users or other unlicensed devices, and must not cause harmful interference." Should any harmful interference occur, the operator of a Part 15 device "is required to immediately correct the interference problem, even if correction of the problem requires ceasing operation."); Julius Knapp, Chief, Off. of Eng'g & Tech, FCC, *Industry Makes Progress on Unlicensed LTE Coexistence* (Sept. 23, 2016), at https://www.fcc.gov/news-events/blog/2016/09/23/industry-makes-progress-unlicensed-lte-coexistence (in the LTE context, the industry created standards including Wi-Fi, Bluetooth, and Zigbee within the FCC's regulatory framework for cooperative sharing of "spectrum by unlicensed devices while recognizing that such devices are not protected from interference.").

[12] *See, e.g.*, *Texas Instruments Comments* at 1, 11; *Vayyar Comments* at 7 ("burden of coexistence should be shared by all the users of the [60 GHz] band, each working primarily to assure the robustness of their technology rather than imposing barriers on other users of the band.").

[13] *FB/Intel/QC Comments* at 11-13.

[14] Comments of Blu Wireless, Inc. in ET Docket No. 21-264 at 1 (filed Sept. 20, 2021) (*Blu Wireless Comments*).

Facebook, Intel, and Qualcomm continue to assert—without evidence—that WiGig-based AR/VR/XR systems cannot reasonably coexist in the presence of low-power radars, including radars that operate under the 10% duty cycle limit Facebook and Qualcomm endorsed in 2018 for the *Soli Waiver Order*.[15] The three companies also assert—again without technical justification—that the Commission must require "any off-time period between two successive radar pulses that is less than 2 [millisec] be considered 'on time' for purposes of computing the duty cycle."[16] The lack of evidence behind either of these claims stands in stark contrast to measurement studies submitted to the Commission by Google in 2018 (and again with its comments in this docket)[17] and Infineon in 2021.[18] These studies demonstrate that low-power radars have *de minimis* impact on nearby WiGig systems, which is limited to extreme "corner case" conditions in which the radar and WiGig devices are within tens of centimeters of each other and are pointed directly at one another.

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[15] *See In the Matter of Google LLC Request for Waiver of Section 15.255(c)(3) of the Comm'n's Rules Applicable to Radars Used for Short-Range Interactive Motion Sensing in the 57-64 GHz Frequency Band*, Order, 33 FCC Rcd. 12542 n.45 (2018) (*Soli Waiver Order*); Letter from Megan Anne Stull, Counsel, Google LLC, & Pankaj Venugopal, Assoc. Gen. Counsel, Facebook, Inc., to Marlene H. Dortch, Sec'y, FCC, in ET Docket No. 18-70 at 1-2 (filed Sept. 7, 2018) (agreeing that Soli sensors could operate within *Soli Waiver Order* conditions without causing levels of interference that Facebook previously characterized as unreasonable); *See* Letter from John W. Kuzin, Vice President and Regul. Counsel, Qualcomm Inc., to Marlene Dortch, Sec'y, FCC, in ET Docket 18-70 (filed Nov. 16, 2018) (fully supporting Soli waiver approval according to terms presented in the Google/Facebook joint filing).

[16] *FB/Intel/QC Comments* at 13.

[17] *Google Comments* at Attachments A, C, D (appending Jian Wang & Jaime Lien, *Gesture Classification Performance Estimate Under Regulatory Limits* (Oct. 2018) at Attachment A; Qi Jiang, *et al.*, *Measurement Study on Soli/802.11ad Coexistence* (June 2018) as Attachment C; and Gary Wong, *et al.*, *Supplement to Measurement Study on Soli/802.11ad Coexistence* (Oct. 12, 2018) as Attachment D). Google also included a study from 2019 with its filing. *See id.* (appending Jian Wang & Jaime Lien, *Gesture Classification Performance Estimate Under Regulatory Limits* (Feb. 2019) as Attachment B).

[18] *See* Letter from Edward A. Yorkgitis, Jr., Counsel to Infineon Techs. Ams. Corp., to Marlene H. Dortch, Sec'y, FCC, in GN Docket No. 14-177, at 1-2 (filed June 23, 2021).

Simulation studies also conducted by Google in 2018 and submitted with its comments in this proceeding,[19] as well as the basic physics of mmWave propagation, corroborate these results. mmWave communication systems have a very narrow spatial window, in terms of distance, direction, and even polarization, in which appreciable interference from other systems can be received. In fact, the worst-case examples illustrated in the *FB/Intel/QC Comments*—such as a user with a head-mounted display or HMD sitting at a desk with a 60 GHz radar device[20]—appear to be precisely the type of environment in which Google's and Infineon's studies showed essentially no impact to WiGig due to lack of spatial alignment (i.e., the WiGig device is not precisely pointed at the radar).

Furthermore, as explained in Google's comments, WiGig systems can send vast amounts of data in the time periods (e.g., 200 microseconds, in the case of the Nest Hub device) between radar transmissions.[21] Thus, claims that radar duty cycles "block[] other operations and impact[] the ability of communications applications to meaningfully utilize the spectrum", are incorrect.[22]

Facebook, Intel, and Qualcomm rightly warn against "[g]iving one technology precedence over another[,]" due to the potential for "ineffective use of the band."[23] The record, however, reflects how their proposed 2 millisec condition would lead to exactly this result. Parties explain how radar device performance would be

[19] *Google Comments* at Attachments E, F (appending Dr. Stefan Mangold, *Assessing the Interference of Miniature Radar on Millimeter Wave 60 GHz Wi-Fi: Simulation Study* (Feb. 21, 2018) as Attachment E and Dr. Stefan Mangold, *Assessing the Interference of Miniature Radar on Millimeter Wave 60 GHz Wi-Fi — Supplemental Analysis* (June 8, 2018) as Attachment F).
[20] *FB/Intel/QC Comments* at 8.
[21] *Google Comments* at 21-22.
[22] *FB/Intel/QC Comments* at 2.
[23] *Id.* at 3.

harmed through significantly lower velocity resolution/aliasing and artifacts in Doppler processing.[24] Other radar use cases would be eliminated entirely.[25] Tailoring rules to provide "single digit millisecond latency"[26] for Facebook's, Intel's, and Qualcomm's own anticipated applications would swallow the potential for many existing unlicensed applications to use the 60 GHz band—the antithesis of reasonable coexistence. The Commission therefore should resist adopting the "protective parameters"[27] sought by Facebook, Intel, and Qualcomm, which mirror levels that are generally reserved only for licensed technologies.

The Commission likewise should reject Blu Wireless's claims that regulatory changes are unnecessary because "radar operations can be achieved using the native IEEE 802.11ad protocol."[28] 802.11ad does include a specific spread spectrum phase-modulated radar implementation, but that type of radar is inferior for a number of use cases for reasons including performance, complexity, and cost. Frequency-Modulated Continuous Wave (FMCW) radars, for instance, have much simpler digital architecture requirements, are typically lower cost, and can operate in very large bandwidths for fine spatial resolution without significantly increasing power consumption.[29] Likewise, broader implementations of pulse radars not included in

[24] *Vayyar Comments* at 6; *Amazon Comments* 10-11; Comments of Valeo N. Am., Inc. in ET Docket No. 21-264 at 8-9 (filed Sept. 20, 2021); Comments of Inxpect SpA in ET Docket No. 21-264 at 3 (filed Sept. 21, 2021).
[25] Comments of Axis Commc'ns in ET Docket No. 21-264 at 1 (filed Sept. 20, 2021) ("resulting maximum ambiguous velocity . . . is too low for surveillance applications").
[26] *FB/Intel/QC Comments* at 3-4.
[27] *Id.* at 4.
[28] *Blu Wireless Comments* at 4.
[29] *See, e.g.,* radartutorial.eu, *Frequency-Modulated Continuous-Wave Radar (FMCW Radar)*, https://www.radartutorial.eu/02.basics/Frequency%20Modulated%20Continuous%20Wave%20Radar.en.html (last visited Oct. 18, 2021).

802.11ad offer benefits like compact form factors and low power consumption.[30] While Google supports utilization of 802.11ad radars where appropriate, the Commission's rules should remain technology-neutral and not favor this type of radar to the effective exclusion of others.

III. UPDATED RULES WILL NOT ENDANGER EESS OPERATIONS

Google recognizes the need to protect critical sensors on board current and future remote sensing satellites. However, concerns about the impact to operation of EESS (passive) remote sensing satellite observations from airborne use of low-power radar devices operating in the 57-59.3 GHz ("57 GHz") band are misplaced. In particular, the National Academy of Sciences' Committee on Radio Frequencies (CORF) expresses concern about potential interference to EESS from airborne use of field disturbance sensors,[31] and refers to a Google study[32] showing that interference from airborne use of Soli 60 GHz motion sensing radar will not cause interference to EESS systems. CORF's assertions about assumptions made in that study are erroneous or immaterial, as we show below.

Airplane Window Attenuation. CORF implies[33] that Google relied on what CORF believes is a faulty third-party study to assume that airplane windows provide 11.6 dB of

[30] *See, e.g., Acconeer Comments* at 2.
[31] Comments of the Nat'l Acad. of Sci.' Comm. on Radio Frequencies in ET Dkt. No. 21-264 (filed Sept. 20, 2021) (*CORF Comments*).
[32] *See Google Comments* (appending Andrew W. Clegg, PhD, *Compatibility Between Earth Exploration-Satellite Service Sensors and Airborne Use of Project Soli Devices at 57.5 to 63.5 GHz* (June 2018) as Attachment G) (*Clegg Study*). *See also* Letter from Megan Anne Stull, Counsel, Google LLC, to Marlene H. Dortch, Sec'y, FCC, in ET Docket No. 18-70 (filed June 8, 2018) (also appending the *Clegg Study*).
[33] *See CORF Comments* at 15-16 (noting that *"in considering the transmission of Soli emissions through aircraft windows, Google cites* an analysis by Zodiac Aerospace that contains several manifest errors . . . [and] grossly overestimates window attenuation.") (emphasis added).

attenuation. Google's analysis *does not* in fact rely on this study and instead assumes that airplane windows *provide no attenuation at all*. The Google study specifically states that "attenuation of the window is taken to be 0 dB."[34] It also reiterates in a section entitled "Additional Factors Not Included in the Margin Calculation" that "attenuation out of the airplane windows" was not a factor included in the study's calculations.[35]

Internal Reflection of Aircraft Windows. CORF suggests that the conclusions of the Google study depend on the assumption of total internal reflection of aircraft windows at incidence angles greater than 79 degrees.[36] While some analysis was cut off at an angle of 79 degree incidence for convenience, this is demonstrated to make less than ~1 dB difference to the Google study's conclusions.

Specifically, figures 2-4 of the Google study show that projecting the beam pattern of a handheld user device out of the window of a plane does not result in reaching an incidence angle of 79 degrees in any normal situation.[37] For example, the worst-case geometry analyzed (figure 3 of the Google study) represents a handset in the lap of a passenger sitting in a window seat such that the device is 19 inches below the window and only 9 inches inward from the window.[38] This results in an incidence angle on the window of no more than about 70 degrees. As noted above, the Google study does not apply any attenuation of the window in any case.

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[34] *See Clegg Study* at 4. *See also id.* at 13, 18 (Including a chart listing individual factors taken into account to calculate the interference margin, which does not include any window attenuation factor and stating that "[a]ll interference margins would be increased by more than 11.6 dB … taking into account the attenuation of the airplane windows…").
[35] *Id. at 18*.
[36] *CORF Comments* at 18.
[37] *Clegg Study* at 5-6.
[38] *Id.* at 5.

Regardless, the difference in atmospheric attenuation between the 79 degree angle cut-off used in the study, and the worst-case vertical incidence (90 degrees), is insignificant. The difference between 57.5 GHz attenuation on a 79 degree slant path from 40,000 ft (25 dB) compared to attenuation straight up (24 dB) is only 1 dB.[39] This frequency represents the lowest attenuation for any frequency on which Soli operates. Furthermore, the difference at higher Soli frequencies is shown to be even less (less than 0.3 dB): The simulations show that in a 1 MHz channel, the minimum atmospheric attenuation on a 79 degree slant path is approximately 17.8 dB (near 57.9 GHz). For the worst-case 'straight-up' path, the minimum attenuation is ~17.5 dB in 1 MHz, and ~17.6 dB over 100 MHz.[40]

Reflection off Airplane Wings. CORF notes that studies did not take reflections off of airplane wings into account.[41] This seems entirely appropriate given the unusual position a user would have to be in for significant emissions to point out of the window and down toward the wings. The Soli radar emissions at issue in Google's study, for example, are beamed out of the front of the phone. Therefore, a user would have to have the front of their phone pointed out of the window and downward. The user would have difficulty viewing the screen in this configuration, let alone using hand gestures to control any interaction with content on the screen.

NTIA Request for Further Study. Apart from CORF's misplaced concerns, NTIA requests that the Commission further study potential impacts to EESS before adopting

[39] *Id. at* 14.
[40] *Id.* at 15.
[41] *CORF Comments* at 17 (stating that "neither the Zodiac Aerospace Study nor the AVSI Study appear to consider reflection off the aircraft wings").

rules.[42] The purpose of comments in this proceeding is in fact to provide the Commission with substantial record evidence that supports action and makes other studies outside the record unnecessary. Indeed, any analysis by the Government of potential interference to EESS should be conducted in an open and transparent process (i.e., this proceeding), and should not be conducted without active involvement of industry.

CONCLUSION

Updates to the Commission's rules are necessary to realize the full potential of the 60 GHz band. Commenters throughout the 60 GHz ecosystem agree that regulations based on ETSI standard EN 305 550 would foster both fairness and innovation. Regardless of the exact framework on which they are based, however, modernized rules for the 60 GHz band should seek to maximize reasonable coexistence and technological neutrality among unlicensed technologies. Opening 60 GHz spectrum to more intensive use, especially by low-power radars, would not pose a greater threat of harmful interference to EESS operations in the band, which have priority. The Commission should act expeditiously to update its rules consistent with Google's comments in this proceeding.

[42] Comments of the Nat'l Telecomms. and Info. Admin. in ET Docket No. 21-264 at 1 (filed Sept. 20, 2021).

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October 18, 2021